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PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

Improvements relating to Refrigerating Apparatus.

We, Albert Einstein, of 5, Haberlandstrasse, Berlin, W. 30, Germany, a citizen of Switzerland, and Leo Szilard, of 95, Prinzregentenstrasse, Berlin-Wilmersdorf, formerly of Faradayweg 16, Berlin-Dahlem, Germany, a Hungarian citizen, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to refrigerating apparatus having a refrigerant evaporated in the evaporator by the introduction of a pressure equalising auxiliary medium thereinto and separated from said medium by the absorption of the latter and condensation of the refrigerant as described in British Patent Specification No. 250,983.

According to the present invention the refrigerating process in such apparatus is carried out by utilising ammonia as the auxiliary medium, water as the absorption medium and butane or methyl-bromide as the refrigerant.

When utilising the above substances in the refrigeration process the condensation of the refrigerant and the absorption of the auxiliary medium is preferably effected in known manner in the same vessel which is hereinafter called a condenser-absorber.

As no condensation of the auxiliary gas is required, the apparatus is further worked with ammonia as the auxiliary gas at any desired small total pressure. The total pressure is practically the same in all parts of the apparatus except the pressure differences counterbalanced by the hydrostatic pressure of liquid columns.

The invention will be hereinafter more particularly described with reference to the accompanying drawings in which:—

Fig. 1 shows diagrammatically one embodiment of the invention.

Fig. 2 is a modification of the invention.

Fig. 2a is a section on the line A—A of Fig. 2.

Figs. 3 and 4 are further modified arrangements of the invention.

Referring to Fig. 1 showing one embodiment of the invention, 1 designates the evaporator containing a cooling agent 2, in this case methyl bromide. Through the pipe 3 gaseous ammonia enters the evaporator and flows from this pipe 3 into the cooling agent through a distributor 4. Divided into numerous small bubbles the gaseous ammonia then rises through the liquid cooling agent 2 and in this manner becomes saturated very completely with the vapour of the methyl bromide. The mixture of the two gases then flows through the conduit 5 into the condenser-absorber 6 into which water is dropping continuously through the conduit 7. Preferably the water flows along the wall 8 of the condenser which wall is cooled by external cooling water.

The saturation pressure of the ammonia being strongly reduced in the presence of water the gaseous ammonia will be absorbed by the water, the gas content of the condenser 6 being thus deprived of said gaseous ammonia. As the total pressure remains constant in this process, the partial pressure of the methyl bromide will be correspondingly increased on account of the removal of the gaseous ammonia, especially adjacent the walls, so that the vapour of methyl bromide will become super-saturated and will be condensed on the walls of the condenser simultaneously with the absorption of ammonia. Gaseous ammonia and vapour of methyl bromide tend simultaneously to approach the walls of the condenser and the condensation proceeds very rapidly; the velocity of condensation depending in the first place on the speed with which the heat is removed from the walls of the condenser. The condensed methyl bromide has a higher specific weight than the ammonia solution and collects in the condenser as at 9, whereas the ammonia mixture 10 floats above.

The methyl bromide in the condenser communicates with that in the evaporator by means of the conduit 11. 12 designates a cooling jacket for cooling the condenser 6. The ammonia solution is transferred into the vessel 15 through the pipe 13 by means of gas bubbles ris-

ing in the pipe 14, said gas bubbles being formed by heating said pipe 14 so that gaseous ammonia is driven out from the water rich in ammonia. In the vessel 15 the bubbles of gas are separated from the water, and the gas thus liberated enters the condenser 6 through the pipe 16, the quantity of such gas being only small and being ineffective for the useful work of the apparatus.

The water rich in ammonia is deprived of ammonia in the generator 17 which it enters from the vessel 15 through the pipe 18, the generator being disposed at a lower level than the vessel 15 which communicates with the condenser 6 through the pipe 16. As the total gas pressure in the vessel 15 is equal to that in the condenser 6 and to that in the evaporator 1 above the liquid level of the methyl bromide, the gas pressure in the generator 17 is higher by an amount corresponding to the hydrostatic pressure of the liquid column h in the pipe 18. By this means the gaseous ammonia will be forced from the generator 17 through the pipe 3 into the evaporator beneath the liquid level of the methyl bromide, provided that the hydrostatic pressure of the column h is higher than that of the column h_1 of the methyl bromide.

On account of the super pressure in the generator 17, the water deprived of ammonia is again forced into the condenser 6 through the pipe 7. Throttling means must be provided, as otherwise too much liquid would be driven into the condenser from the generator on account of the super pressure. Preferably the opening 19 of the pipe 7 is provided with a porous cap through which liquid may pass but through which no gas can flow when the liquid level in the generator has descended below said cap, the capillary action preventing the liquid from being pressed out of the pores by the gas.

As the water poor in ammonia should enter the condenser through the pipe 7 in a cold condition, the pipes 7 and 14 may be combined in a heat exchanger (not shown in Fig. 1) whereby the pipe 7 may be further cooled. In the same manner the pipes 5 and 11 may also be combined in a heat exchanger. In this way vapour of methyl bromide will be continuously carried away from the evaporator by the gaseous ammonia, cold being produced by the evaporation of the methyl bromide.

It is of the utmost importance that the pressure of the ammonia in the generator is chosen in a suitable manner. When working with very small pressure of the ammonia, the cooling effect of the apparatus will be very small. On the contrary the pressure of the ammonia vapour in the generator has a definite upper limit. This may be easily proved by a calculation which also gives an idea of the manner of dimensioning the apparatus. Assuming the temperature of the cooling water to be 25° C. and consequently that of the condenser also to be 25° C. and the temperature in the evaporator −5° C., then it is, for instance, quite impossible to operate with a pressure of ammonia vapour of 10 atm. in the generator as the total pressure is approximately the same in all parts of the apparatus. As substantially only gaseous ammonia is evolved in the generator, the partial pressure of the ammonia in the same would, consequently, be equal to the total pressure, i.e., 10 atm. In the evaporator the partial pressure of the ammonia must be smaller than the pressure of saturation of ammonia at −5°, that is to say smaller than approximately 3 1/2 atm. As the total pressure in the evaporator is also 10 atm., then the partial pressure of the cooling agent in the evaporator must, consequently, amount to 6 1/2 atm. However, the partial pressure of the ammonia in the condenser is always above zero so that in this vessel less than 10 atm., must be taken up by the cooling agent.

When assuming a temperature of the condenser of 25° C., the vapour of the cooling agent must, consequently, be saturated at a lower pressure than 10 atm., but it has been shown above that the pressure of saturation at −5° cannot amount to more than 6 1/2 atm. The ratio of the pressures of saturation of the cooling agent at 25° and −5° should consequently be smaller than 10 : 6,5, i.e., 1.54. A substance that can be used as cooling agent under these circumstances and for which this ratio is so low is probably impossible to find. From this it is evident that it is necessary in all cases to operate with pressures of gaseous ammonia that are far below 10 atm. Consequently, any condensation of the gaseous ammonia driven out cannot take place at room temperature or normal temperature of cooling water, so that the ammonia in all cases enters the evaporator containing the cooling agent with certainty in a gaseous state. When operating with relatively high temperatures of gaseous ammonia then at low temperatures in the evaporator, condensation and re-evaporation of the gaseous ammonia may occur. It is evident that in this case heat of evaporation of the ammonia does not partake in the cooling effect of the apparatus as on evaporation of the condensed ammonia only the heat is re-

moved that is liberated on condensation.

Fig. 2 shows another embodiment of the invention. It is also assumed in this case that the cooling agent has the higher specific gravity. In this embodiment the water rich in ammonia leaves the condenser 20 and is raised to the point P by the aid of gas bubbles in the pipe 21 which forms a heat exchanger together with the pipe 22 through which the water weak in ammonia leaves the generator 23. From pipe 21 the water still rich in ammonia flows over the fins of the pipe 21 in the pipe 24, which is shown in section in Fig. 2a, downwardly into the generator 23. The gaseous ammonia driven out which may contain steam rises in the pipe 24 and will in this manner come into intimate contact with the water rich in ammonia dropping downwards. In this manner cooling of said gaseous ammonia will be effected and, further, the vapour of ammonia will be deprived of any steam entrained therewith, in that ammonia will be vaporised from the water rich in ammonia by absorption of heat from the mixture of gaseous ammonia and steam. The separation of steam will be effected firstly by the cooling abovementioned and secondly by the fact that the partial pressure of the steam in the water rich in ammonia is decreased. The vapour of ammonia thus cooled and deprived of water is conducted into the evaporator through the pipe 25. The manner of operation of the apparatus shown in Fig. 2 is otherwise the same as that of the embodiment shown in Fig. 1.

Fig. 3 shows diagrammatically a third embodiment. Contrary to the two embodiments described above the cooling agent is in this embodiment assumed to be butane which has a smaller specific weight than the mixture of ammonia water. The water rich in ammonia 26 flows through the pipe 27 and the heat exchanger 28 into the generator 29 in which the ammonia is driven out by heating and supplied to the evaporator through the pipe 30. The gaseous ammonia in the generator stands under a pressure of a liquid column h_1 and this pressure is sufficient to permit the gaseous ammonia to enter the evaporator as at 31 beneath the liquid level of the cooling agent (the butane). It is only necessary that the height of the liquid column h_1 is greater than that of h_2.

Opening into the container 33 is a pipe 32 extending upwards from the generator 29. Through said pipe 32 the water poor in ammonia is raised by means of gas bubbles into the container 33 in which the water is deprived of its gas bubbles. From this container 33 the gas flows through the pipe 34 into the condenser 35 and is lost for useful work in the apparatus. Heat may be supplied to the portion 36 of the pipe 32 in order to produce the gas bubbles necessary to transport the water. From the container 33 the water poor in ammonia flows under the action of gravity through the pipe 37 into the condenser 35 in which it drops downwardly. The pipe 37 extends above the heat exchanger 28, and the water poor in ammonia contained therein is further cooled by cooling water, before it enters the condenser. This is indicated in the drawing by the fact that the pipe 37 is shown passing through the cooling jacket of the condenser. The gaseous ammonia leaving the generator may in known manner be conducted through an ascending branch of the pipe 30 through a cooler whereby the ammonia is deprived of any steam entrained therewith (not shown in Fig. 3).

Fig. 4 shows an embodiment in which the cooling agent has the lower specific weight as in the embodiment shown in Fig. 3. Contrary to the embodiments described above the mixture of vapours from the evaporator enters the ammonia water solution in the condenser through the pipe 38 at 39 in which gas bubbles rise in the liquid, the ammonia being absorbed and the cooling agent being condensed. The circulation of the liquid between the condenser 40 and the generator 41 is maintained essentially on account of the difference in specific weight between the mixture rich in ammonia and that poor in ammonia.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. Refrigerating apparatus having a refrigerant evaporated in the evaporator by the introduction of a pressure equalising auxiliary medium therein and separated from said medium by the absorption of the latter and condensation of the refrigerant in which the refrigerant consists of butane. the auxiliary medium of ammonia, and the absorption medium of water.

2. Refrigerating apparatus having a refrigerant evaporated in the evaporator by the introduction of a pressure equalising medium therein and separated from said medium by the absorption of the latter and condensation of the refrigerant. in which the refrigerant consists of methyl-bromide the auxiliary medium of ammonia. and the absorption medium of water.

3. Refrigerating apparatus according to

Claim 1 or 2 in which the condensation of the refrigerant and the absorption of the auxiliary medium is effected in one and the same vessel, namely a condenser-absorber.

4. Refrigerating apparatus according to Claims 1 or 2, and 3, in which the absorbed auxiliary medium is again expelled in a generator and on passing from said generator is led in heat exchanging relation with concentrated solution of auxiliary medium in absorption medium flowing into the generator from the condenser-absorber.

5. Refrigerating apparatus according to Claim 4 in which the auxiliary medium leaving the generator comes in direct contact with the concentrated solution flowing to said generator.

6. Refrigerating apparatus having a refrigerant evaporated in the evaporator by the introduction of a pressure equalising auxiliary medium, constructed, arranged, and operating substantially as described with reference to the accompanying drawings.

Dated the 16th day of December, 1927.

FRANK WATSON,
155, Regent Street, London W. 1,
Agent for the Applicants.

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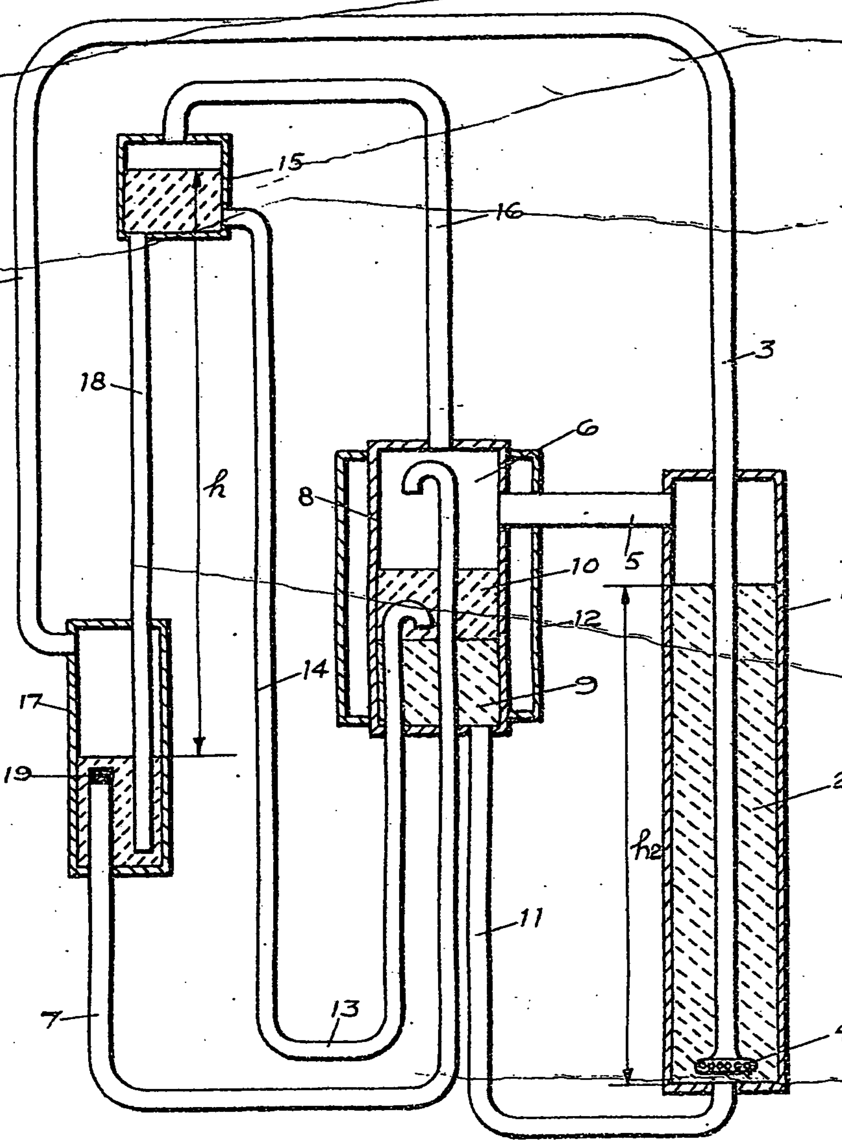
SHEET 1

FIG. 1.



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SHEET 1

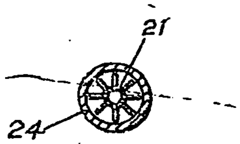

FIG. 2a.

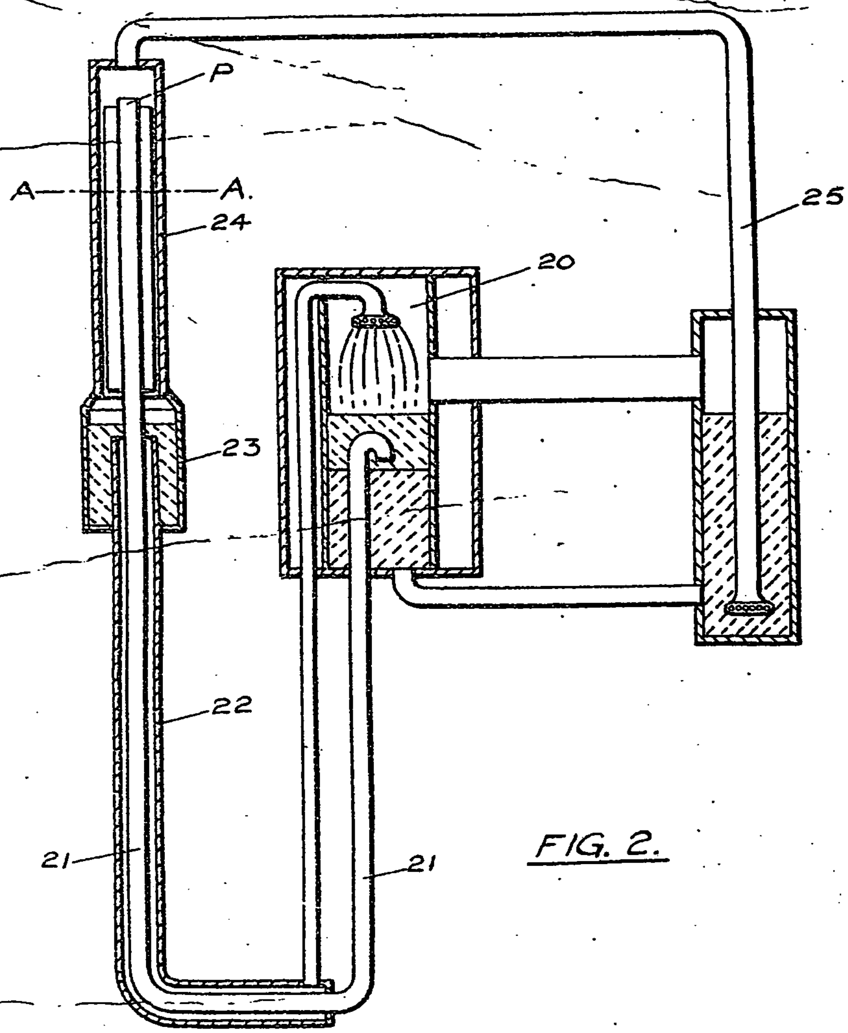

FIG. 2.

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FIG. 1.

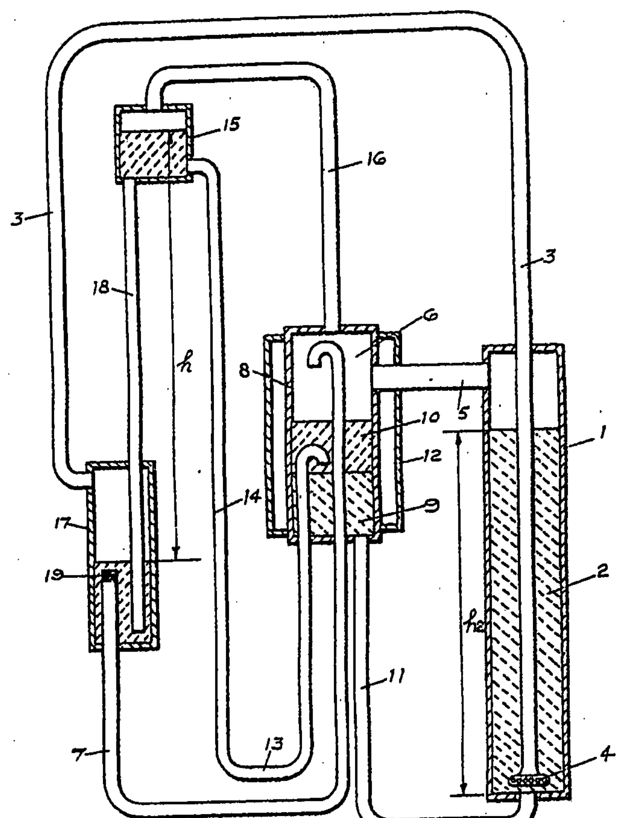

FIG. 2a.

FIG. 2.

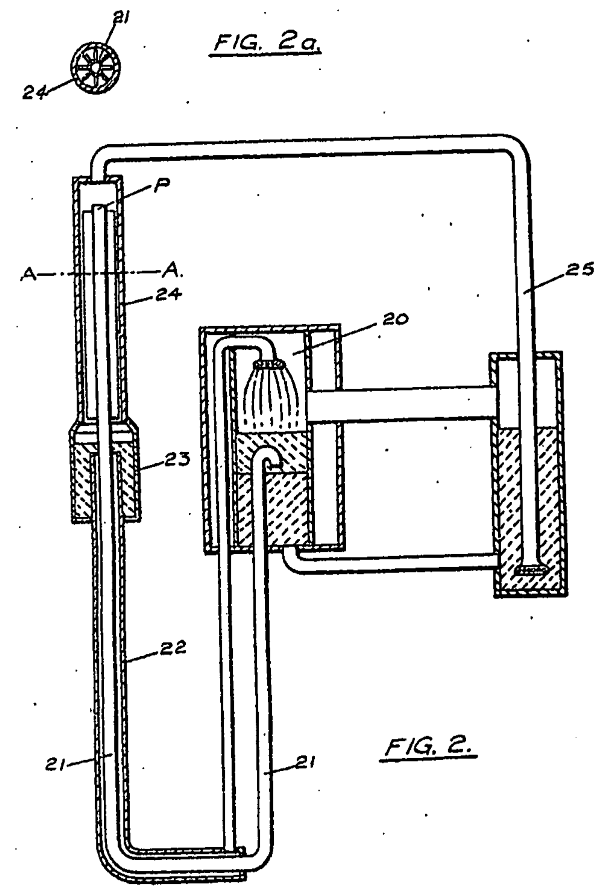

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FIG. 3.

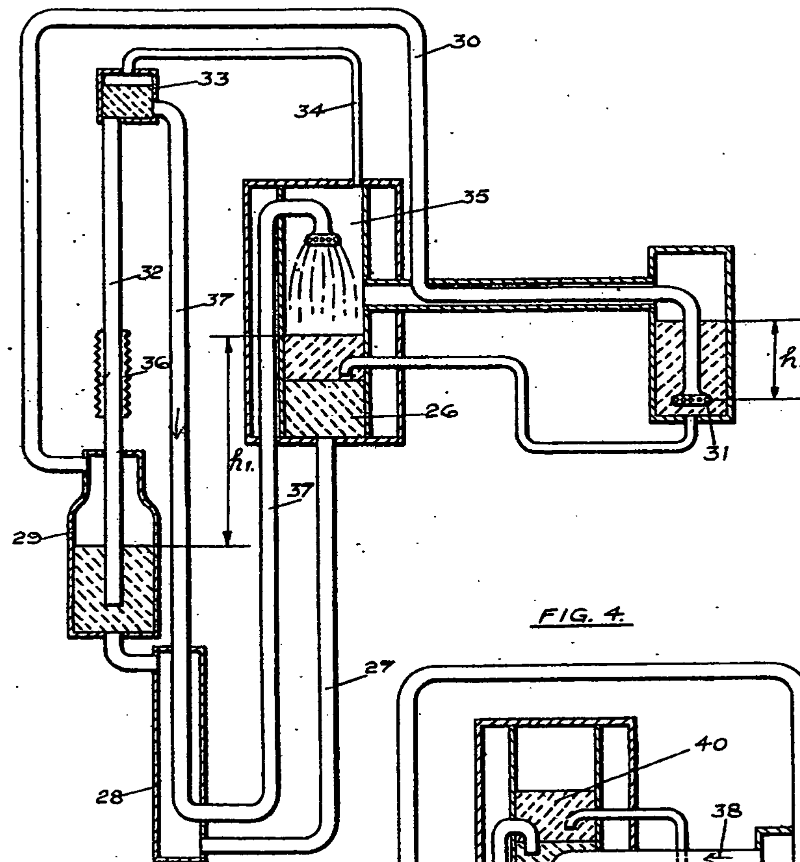

FIG. 4.